POTOMAC RIVER BASIN

STUMP RUN, FRANKLIN COUNTY

PENNSYLVANIA

LEVEL II

CALEDONIA WATER COMPANY DAM

NDI ID NO. PA-1143

DER ID NO. 28-108

HERBERT R. GSELL

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

Prepared By

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG, PENNSYLVANIA
15931

FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT CORPS OF ENGINEERS
BALTIMORE, MARYLAND
21203

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AUGUST 1981

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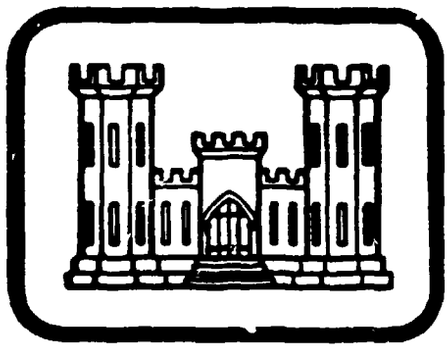

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in detemining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION REPORT

NAME OF DAM	Caledonia Water Company Dam
STATE LOCATED	Pennsylvania
COUNTY LOCATED	Franklin
STREAM	Stump Run
DATES OF INSPECTION	April 23, 1981 and May 12, 1981
COORDINATES	Lat: 39° 53.4' Long: 77° 30'

ASSESSMENT

The assessment of Caledonia Water Company Dam is based upon visual observations made at the time of inspection, review of available records and data, hydraulic and hydrologic computations and past operational performance.

The Caledonia Water Company Dam appears to be in fair condition but poorly maintained. Surface erosion has caused silt and sand to be deposited at the toe of the dam, in the area of the drainline outlet. The outlet was not visible during the inspection. Soil erosion deposits have been allowed to continue unchecked and have apparently covered the outlet. No determination could be made with regards to the condition of the drainline and outlet.

A seepage area was observed at the downstream toe of the dam near mid-embankment. Seepage at the location was estimated to equal 1 gallon per minute. The cause of the seepage should be investigated, and its potential affect on the long term stability of the structure determined.

Final construction of proposed modifications may not have been completed. No drainline control facility exists to regulate flow through the drainline, and final seeding of the embankment crest and slopes were either unsuccessful or never completed.

Observed obstructions at the entrance to, and in, the principal spillway channel, were noted as having a potential effect on the discharge capacity of the spillway.

The Caledonia Water Company Dam is a high hazard-small size dam. The recommended spillway design flood (SDF) for a dam of this size and classification is in the range of 1/2 PMF to PMF. The spillway design flood has been selected as the PMF.

CALEDONIA WATER COMPANY DAM
PA 1143

The visual observations, review of available data, hydrologic and hydrualic calculations and past operational performance indicate that the Caledonia Water Company Dam is capable of controlling approximately 29% of the PMF. The breach analysis and downstream routing of the flood wave did not indicate any increased potential for loss of life from that which existed just prior to failure of the dam. Therefore, the spillway is termed inadequate, but not seriously inadequate.

The following recommendations and remedial measures should be instituted immediately.

1. A detailed hyrologic and hyraulic analysis should be conducted by a registered professional engineer knowledgeable in dam design and analysis to increase the spillway capacity.

2. The location of the water supply line should be determined and if the line passes through the embankment, provisions should be made for upstream closure of the line.

3. The outlet for the drainline should be located and uncovered. The condition of the exposed portion of the drainline and outlet should be determined. Necessary modifications in the area of the outlet should be made to insure the outlet remains visible and clear of the erosion debris.

4. The existence of a drainline control valve at the upstream end of the drainline should be verified. Control facilities for the valve should be made accessible for future use and inspection. It should be ascertained whether or not the valve is operable. If it is determined that the valve is operable, it should be operated and lubricated on a regular basis. If it is determined that the valve is not operable or non-existent, some means should be developed to drain the reservoir which does not include a pressurized line through the embankment.

5. The cause of the observed seepage should be investigated and its long term effect on the stability of the structure evaluated. The investigations should be conducted by a registered professional engineer knowledgeable in dam design and analysis. Remedial modifications should be conducted if required as a result of the evaluation.

6. The observed obstructions in the spillway should be removed. If the purpose of the obstructions placed in the spillway was to keep fish in the reservoir or collect debris at the entrance to the spillway, some other means should be devised for those purposes which does not retard the discharge potential of the spillway.

7. It should be determined whether the dam meets final design requirements associated with modifications required as part of the original permit application for the structure. If it is determined that the dam does not meet the designed modifications the owner should complete work on the structure as required, considering also the findings and recommendations of this inspection.

8. The embankment crest and slopes should be seeded to provide protective vegetation for the crest and slopes. Continued erosion in the area could lead to potential failure of the structure. Existing erosion areas should be repaired.

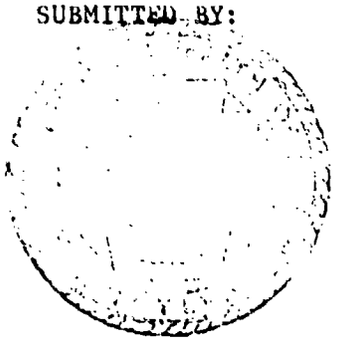
9. A warning system should be developed to warn downstream residents of large spillway discharges or imminent failure of the dam.

10. A regularly scheduled maintenance and operation plan should be implemeted to insure the continued safe operation of the structure.

11. A safety inspection program should be implemented with inspections at regular intervals by qualified personnel.

SUBMITTED BY:

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS AND ARCHITECTS



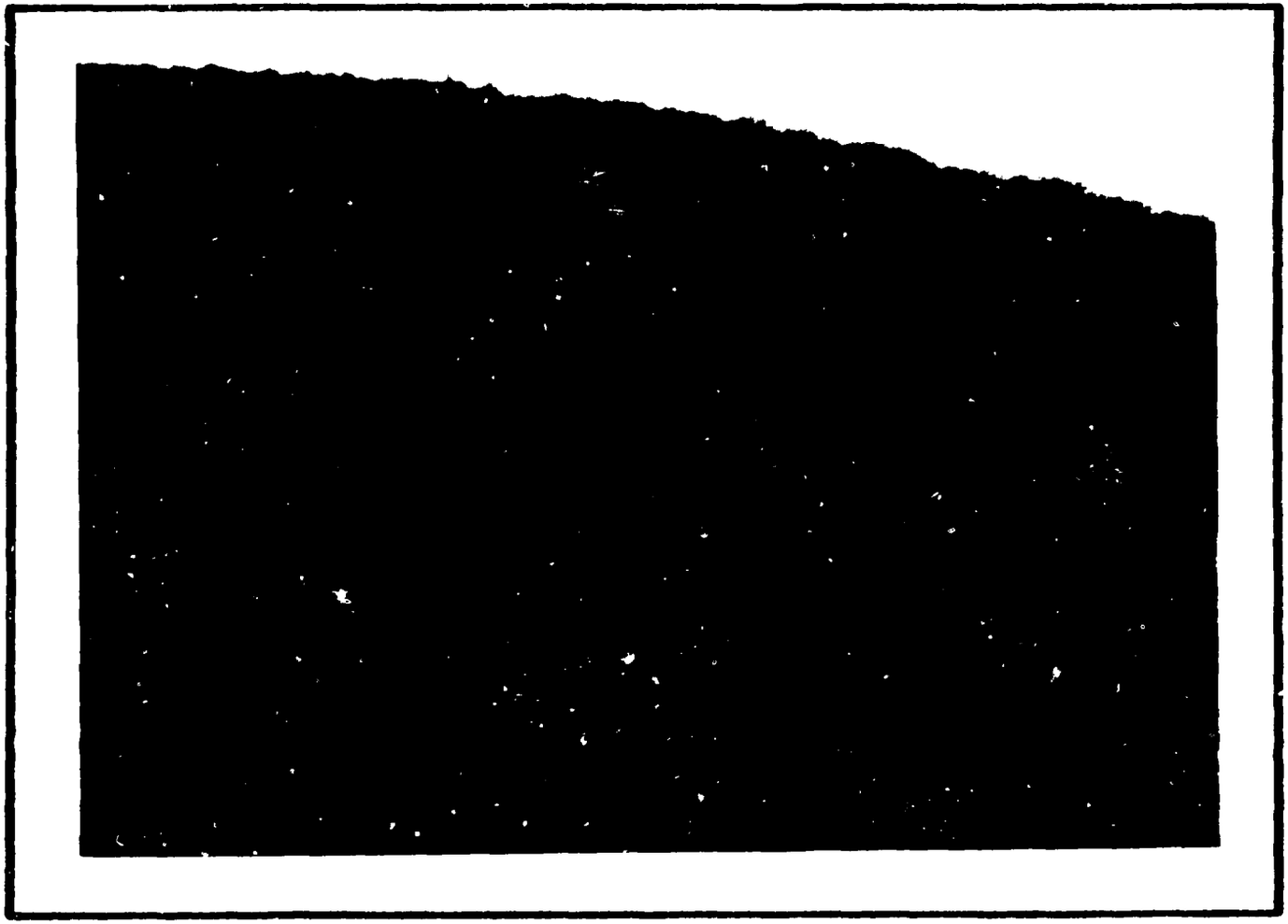
8/6/81
Date

R Jeffrey Kimball
R. Jeffrey Kimball, P.E.

APPROVED BY:

28 Aug 81
Date

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer



Overview of Caledonia Water Company Dam.

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PHASE I
NATIONAL DAM INSPECTION PROGRAM

CALEDONIA WATER COMPANY DAM
NDI. I.D. NO. PA 1143
DER I.D. NO. 28-108

SECTION 1
PROJECT INFORMATION

1.1 General.

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. The Caledonia Water Company Dam is an earthfill dam, 400 feet long and 32 feet high. The crest width of the dam is 12 feet. Both the upstream and downstream slopes are 2.5H:1V.

The spillway is located at the left abutment of the structure. The principal spillway contains a trapezoidal shaped concrete weir, 24 feet long. The channel is approximately 80 feet long and narrows to a width of 10 feet at the outlet. The emergency spillway is a trapezoidal shaped spillway. The emergency spillway is approximately 293 feet long with a bottom width equal to 75 feet.

b. Location. The dam is located on Stump Run, approximately 1.5 miles southwest of Caledonia Park, Greene Township, Franklin County, Pennsylvania. The Caledonia Water Company Dam can be located on the Scotland, PA U.S.G.S. 7.5 minute quadrangle.

c. Size Classification. The Caledonia Water Company Dam is a small size dam (32 feet high, 17 acre-feet).

d. Hazard Classification. The Caledonia Water Company Dam is a high hazard dam. Downstream conditions indicate that the loss of more than a few lives and property damage is probable should the structure fail. Several occupied trailers are located approximately 1/2 mile downstream of the dam along the stream, and are within 5 feet of the water surface elevation.

A small cottage (unoccupied at the time of inspection) exists approximately 2500 feet downstream of the dam, near the edge of the stream and within 5 feet of the water surface elevation. Several trailers are located approximately 1/2 mile downstream of the dam along the stream and are also within 5 feet of the water surface elevation.

e. Ownership. The Caledonia Water Company Dam is owned by Mr. H.R. Gsell. Correspondence should be addressed to:

Mr. H.R. Gsell
Caledonia Water Company
486 Perry Road
Fayetteville, Pennsylvania 17222
717/352-3231

f. Purpose of Dam. The dam is utilized for a water supply storage reservoir.

g. Design and Construction History. The dam was constructed just prior to 1968. The dam was located after a complaint was registered by a downstream property owner who complained about the lack of water in the stream. In August 1968, the state ordered that the dam be breached until a permit for the structure was obtained.

The owner retained the services of Mr. William E. Sees, Jr., a consulting engineer from Harrisburg, Pennsylvania. During the period of January 1969 through December 1971, a design relative to modifications to the dam was accepted; and construction of the dam was completed, except for final shaping and seeding. No information was available regarding the actual construction of the dam.

h. Normal Operating Procedures. The reservoir is used as a water supply facility. Operations surrounding the use of the facility include the drawing off of water from the reservoir through an undetermined diameter pipe (location unknown), treated as necessary and fed into a local supply system.

1.3 Pertinent Data.

a. Drainage Area. 1.0 square mile

b. Discharge at Dam Site (cfs).

Maximum flood at dam site	Unknown
Drainline capacity at normal pool	Unknown
Spillway capacity at top of dam	1000

c. Elevation (MSL) (feet). - Field survey based on an assumed spillway crest elevation, 1152.0, from design drawings.

Top of dam - low point	1155.0
Top of dam - design height	1156.0
Pool at time of inspection	1152.0
Maximum pool - design surcharge	1156.0
Normal pool	1152.0
Spillway crest	1152.0
Upstream portal - (drainline)	Unknown
Downstream portal - (drainline)	Unknown
Streambed at centerline of dam	Unknown
Maximum tailwater	Unknown
Toe of dam	1122.7

d. Reservoir (feet).

Length of maximum pool	230 feet
Length of normal pool	200 feet

e. Storage (acre-feet).

Normal pool	12
Top of dam	17

f. Reservoir Surface (acres).

Top of dam	2.1
Normal pool	1.2
Spillway crest	1.2

g. Dam.

Type	Earthfill
Length (excluding spillway)	400 feet
Height	32 feet
Top width	12 feet
Side slopes - upstream	2.5H:1V
- downstream	2.5H:1V
Zoning	Unknown
Impervious core	Unknown
Cutoff	Unknown
Grout curtain	Unknown

h. Reservoir Drain.

Note: No information is available relative to the type of drainline, diameter of pipe or length of drainline. Design drawings indicate the existence of a drainline with a control structure at the

upstream end of the pipe. No control structure was observed during the inspection, and the outlet for the pipe was not located during the inspection. A representative of the Pennsylvania Department of Environmental Resources, Mr. Richard Peace, who accompanied the inspection team on the inspection, confirmed the existence of a drainline and pointed out to the inspection team the approximate location of the outlet. The reported location of the outlet was covered with saturated sand and silt, apparently placed in the area due to surface runoff erosion.

i. Principal Spillway.

Type	Trapezoidal shaped earthen channel with a trapezoidal shaped concrete weir
Crest (bottom width)	24 feet
Crest elevation	1152.0
Upstream channel	Lake [unrestricted]
Downstream channel	Earth cut channel to Stump Run

g. Emergency spillway.

Type	Trapezoidal shaped earthen channel with gravel lined bottom
Length of crest (bottom width)	75 feet
Crest elevation	1153.5
Upstream channel	50 foot long approach (75 feet wide)

SECTION 2
ENGINEERING DATA

2.1 Design. Review of available information in the files of the Commonwealth of Pennsylvania, Department of Environmental Resources, revealed that some correspondence, permit information and design drawings regarding the embankment and spillway modifications were available. The most recent design drawing was selected to be included in this report and appears in Appendix E. The design of the modifications to the embankment and spillway were completed by Mr. William E. Sees, Consulting Engineer, Harrisburg, Pennsylvania. No additional information was available for review.

2.2 Construction. No information was available relative to the construction of the dam. Based on information contained in the DER files the existing dam is the result of modifications made to a previous structure.

The existing structure is the result of the design modifications constructed between 1969 and 1971.

2.3 Operation. The structure is presently utilized as a water storage reservoir. Water is drawn from the reservoir through an unknown diameter supply line, treated at a facility located downstream of the dam and fed to the supply system.

2.4 Evaluation.

a. Availability. Engineering data were provided by the Pennsylvania Department of Environmental Resources, Bureau of Dams and Waterway Management. The owner of the dam did not supply any additional information.

b. Adequacy. This Phase I Report is based on the visual inspection and hydrologic and hydraulic analysis. Sufficient information exists to complete a Phase I Report.

SECTION 3
VISUAL INSPECTION

3.1 Findings.

a. General. The onsite inspection of the Caledonia Water Company Dam was conducted by personnel of L. Robert Kimball and Associates on April 23, 1981 and May 12, 1981. Mr. Richard Peace, representing the Pennsylvania Department of Environmental Resources, accompanied the inspection team during the April 23, 1981 inspection. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments and toe.
2. Examination of the spillway facilities, exposed portion of any outlet works and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.
4. Evaluation of the downstream area hazard potential.

b. Dam. The dam appears to be in fair condition. From a brief survey conducted during the inspection, it was noted that the low spot on the embankment crest was located approximately 180 feet right of the principal spillway, near mid-embankment. It was noted during the inspection that the earthen embankment did not contain any surface erosion protection. Embankment erosion was evident, although no significant erosion gullies were observed on the embankment slopes. The material utilized to construct the embankment was noted to be sand. The crest of the dam was measured to be 12 feet wide. The upstream and downstream slopes were measured to be 2.5H:1V. The inspection of the downstream slope of the embankment and toe area disclosed that a minor seepage area existed near the downstream toe of the dam, mid-way across the crest of the embankment. The seepage was estimated to be approximately 1 gallon per minute. It was noted during the May 12, 1981 inspection that the seepage appeared to be equal to that value which was observed during the April 23, 1981 inspection.

c. Appurtenant Structures. The principal and emergency spillways for the structure exist at the left abutment. The principal and emergency spillways are separated by an earth berm. The principal spillway was observed to be a trapezoidal shaped channel cut into natural ground in the area. The entrance to the channel contained a trapezoidal shaped concrete weir. Evenly spaced metal fence posts existed across the entrance to the channel. The line of posts were not considered as being capable of significantly affecting the discharge potential of the spillway. There was nothing attached to

the row of posts which could significantly retard flow in the channel. Immediately downstream of the concrete weir, gravel had been piled in the channel to an elevation just slightly above the concrete weir elevation. The pile of gravel was apparently utilized to keep fish in the reservoir area.

The emergency spillway is located directly left of the principal spillway. The emergency spillway is a trapezoidal shaped channel cut into natural ground. The bottom of the channel was covered with gravel. The bottom width is 75 feet. The left bank of the discharge channel was cut back on a slope of approximately 2.5H:1V. Both the principal and emergency spillways discharge flows beyond the downstream toe of the dam into the natural stream.

Design drawings indicate the existence of a control structure within the reservoir, on the upstream slope of the dam, and a drainline through the reservoir near mid-embankment. No control structure was observed during the inspection. Attempts to locate the outlet for the drainline pipe were unsuccessful. The approximate location of the outlet was pointed out to the inspection team by Mr. Richard Peace, representing the Pennsylvania Department of Environmental Resources, who accompanied the inspection team. The outlet for the drainline pipe was apparently covered by materials placed in the area by surface runoff erosion. A stone wall was observed in the area and may have served as a endwall for the outlet pipe. Immediately downstream from the toe of the dam existed an abandoned weir. DER files indicate that a constant stream flow was to be maintained, and the weir obviously was used to monitor the required stream flow.

No determination could be made of the condition of the drainline, size or type of pipe. The exact location of the pipe through the embankment is unknown and the location of the feed line through the embankment is unknown.

d. Reservoir Area. The watershed is covered almost entirely with forested areas. The reservoir slopes are moderate to steep, but do not appear to be susceptible to landslides which would affect the storage volume of the reservoir or overtopping of the dam by displacing water.

e. Downstream Channel. The downstream channel for the Caledonia Water Company Dam consists of Stump Run. The channel is relatively narrow throughout its entire length, north to Route 30. Just north of Route 30 the Stump Run drains into the Conococheague Creek.

A small cottage (unoccupied at the time of inspection) exists approximately 2500 feet downstream of the dam, near the edge of the stream and within 5 feet of the water surface elevation. Several

occupied trailers are located approximately 1/2 mile downstream of the dam along the stream, and are also within 5 feet of the water surface elevation.

3.2 Evaluation. In general, the dam and observed appurtenant structures appear to be in fair condition. The existence of a drainline through the embankment was verified by a representative of the Department of Environmental Resources, although the outlet for the pipe could not be located. This condition apparently signifies the lack of maintenance of the structure. Maintenance of the drainline facilities is considered non-existent.

A December 13, 1971 memorandum contained in the files of the Pennsylvania Department of Environmental Resources indicate that an inspection was made at that time; and it was noted that construction of the dam was completed, with the exception of the final shaping and seeding. Apparently, construction of the dam was never entirely completed. No protective vegetation existed on the crest or slopes. The drainline control structure shown on the design drawings was apparently not required as part of the required design modifications, or just never constructed. No facilities were observed during the inspection for regulating flow through the drainline. The existence of an upstream control could not be verified.

The non-existence of vegetation on the embankment crest and slopes has allowed minor erosion to occur across the entire earthen embankment section. The embankment material appeared to be coarse and easily erodible, although no significant erosion gullies were observed during the inspection. The lack of observed fine material on the embankment was possibly due to erosion in the area. This condition, if left unchecked, could lead to significant erosion of the embankment crest and downstream slopes, and could potentially lead to failure of the embankment.

The existence of metal posts along the entrance to the principal spillway and the gravel filling the channel just below the spillway control section do not appear to be part of the design modifications. The existence of the iron posts and gravel in the channel do not appear to immediately affect the discharge potential of the spillway, although the existence of the posts indicate the potential for the retention of materials which could potentially retard the discharge potential for the spillway. The posts should be removed from the approach to the spillway; and the gravel should be spread through the entire length of the channel, or removed from the channel entirely. If the purpose of the structures was to keep fish within the reservoir area, an alternate method should be selected which does not affect the discharge potential of the spillway.

The observed seepage near the downstream toe of the dam should be monitored, and the results of the monitoring submitted to a registered professional engineer for evaluation. The evaluation should include the potential effects of the seepage on the stability of the structure. The outlet for the drainline should be located and sufficiently protected to insure that the line is capable of serving its intended function. The existence of regulating facilities for the drainline should be verified and proper facilties constructed which enable access to the drainline control valve.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures. The reservoir is maintained at the spillway crest elevation. Water is drawn from the reservoir through an unknown diameter feed line apparently through the embankment. The location of the feed line is unknown. A building is located just downstream of the dam which is utilized to control flow through the supply system.

4.2 Maintenance of the Dam. No planned maintenance schedule exists for the dam.

4.3 Maintenance of Operating Facilities. There is no maintenance of operating facilities at the dam.

4.4 Warning System in Effect. There is no warning system in effect to warn downstream residents of large spillway discharges or imminent failure of the dam.

4.5 Evaluation. Maintenance of the dam and operating facilities is considered poor. A maintenance and operation schedule should be prepared and implemented to insure the continued safe operation of the facility.

An emergency action plan should be available for every dam in the high and significant hazard categories. Such plans should outline actions to be taken by the operator to minimize downstream effects of an emergency, and should include an effective warning system. No emergency action plan has been developed, and the owner should develop such an action plan.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features.

a. Design Data. No information relative to the hydraulic design of the spillway were available for review. Available information suggests that the spillways was designed to discharge 1095 cfs.

b. Experience Data. No rainfall, runoff or reservoir level data were available.

c. Visual Observations. Two spillways exist for this structure. Both the principal spillway and emergency spillway are located at the left abutment of the structure. The principal and emergency spillways are separated by an earthen berm.

The principal spillway consists of a trapezoidal shaped channel with a trapezoidal shaped concrete weir. Steel fence posts were observed at the entrance to the spillway, and gravel was piled immediately below the control section in the spillway. The maximum elevation of the gravel in the channel is just slightly above that for the crest of the weir. It is assumed that the gravel is used to keep fish within the reservoir area. It was noted during the inspection that neither the metal posts nor the gravel in the channel would significantly affect the discharge capacity of the spillway. The location of the fence posts provides the potential for materials to be placed against the posts, thus retarding the discharge potential of the spillway. The posts should be removed from the entrance to the spillway, and the gravel should be removed or spread throughout the entire length of the channel. If the purpose of the gravel and/or posts were to maintain fish in the reservoir, an alternate method should be devised which does not affect the discharge potential of the spillway.

The emergency spillway is a trapezoidal shaped channel cut into natural ground at the left abutment. The channel bottom width is 75 feet and the left bank of the channel was cut back on a slope of approximately 2.5H:1V. The channel bottom is lined with gravel. No obstructions were observed in the emergency spillway channel which would affect the discharge potential of the facility.

The low spot on the embankment crest was determined to be at elevation 1155.0. Based on a survey conducted during the inspection, it was determined that the low spot is located near mid-embankment, approximately 180 feet right of the principal spillway.

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for

the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, Baltimore District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydrologic Engineering Center (HEC), U.S. Army Corps of Engineers, Davis, California, July 1978. The major methodologies or key input data for this program are discussed briefly in Appendix D.

5.2 Evaluation Assumptions. To enable completion of the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions.

1. The pool elevation in the reservoir prior to the storm was considered to be at the spillway crest elevation, 1152.0.

2. The top of dam was considered to be the low spot elevation, 1155.0.

3. The minor obstructions in the principal spillway were not considered as being capable of significantly affecting the discharge potential of the spillway. The principal and emergency spillways are trapezoidal shaped but, for the purposes of this analysis, the spillways were analyzed based on the standard weir equation. This approach to the analysis was made due to the relatively low heads associated with discharges through the facilities.

5.3 Summary of Overtopping Analysis. Complete summary sheets for the computer output are presented in Appendix D.

Peak inflow (PMF)	3607 cfs
Spillway capacity	1000 cfs

a. Spillway Adequacy Rating. The Spillway Design Flood (SDF) is based on the hazard and size classification of the dam. The recommended spillway design flood for a dam of this size and classification is in the range of 1/2 PMF to PMF. At least three homes are located within the downstream potential floodwave, adjacent to the stream and within 5 feet of the water surface elevation. Since the height of the dam is at the high end of the small size hazard category the spillway design flood has been selected as the PMF. If the embankment crest is raised to the design elevation 1156, the spillway is capable of passing the 1/2 PMF storm.

Based on the following definition provided by the Corps of Engineers, the spillway is rated as inadequate as a result of our hydrologic analysis.

> Inadequate - All high hazard dams which do not pass the spillway design flood (PMF).

The spillway and reservoir are capable of controlling approximately 29% of the PMF without overtopping the embankment.

5.4 Summary of Dam Breach Analysis. As the subject dam cannot satisfactorily pass at least 50% of the PMF, it was necessary to perform a dam breach analysis and downstream routing of the flood wave. This analysis determines the degree of increased flooding due to dam failure. A pool elevation of 1155.35, representing 4.2 inches of overtopping, was considered sufficient to cause failure of the dam due to overtopping.

The results of the dam breach analysis indicate that the downstream potential for loss of life and property damage is not significantly increased by dam failure. Therefore, the spillway is rated as inadequate, but not seriously inadequate. Details of the downstream routing of the flood wave are included in Appendix D.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations. No slumping or sloughing of the embankment crest or slopes was observed during the inspection. No major erosion areas were observed during the inspection, although no vegetative protection exists on the crest or slopes and the potential for erosion exists.

A small concentrated seepage point was observed near the downstream toe near mid-embankment. The seepage was estimated to be approximately 1 gallon per minute. No change was noted for the observed seepage during the May 12, 1981 inspection from that which existed during the April 23, 1981 inspection.

Continual surface erosion has deposited silt and sandy material at the toe of the dam near the reported location of the drainline outlet. The drainline outlet was unobserved during the inspection due to the erosion deposits.

The dam that existed at the site prior to the modifications to the structure was considered to be potentially statically unstable. Modifications required as part of the permit application include the placement of additional material on the downstream slope of the dam. The existing structure appears to be the result of the design modifications. No major deficiencies were observed during the inspection which were considered as having an immediate effect on the static stability of the structure.

b. Design and Construction Data. Only limited information exists relative to the original structure. Design modifications were required as a result of the owner's application for a permit to maintain the structure as a water supply storage facility.

The modifications to the dam were completed during the period of January, 1969 through December 1971. Mr. William E. Sees, Jr., a consulting engineer from Harrisburg, Pennsylvania, was the design engineer for the modifications. No information was available relative to the actual construction of the dam.

c. Operating Records. No operating records are known to exist for this dam.

d. Post Construction Changes. Based on information contained in the DER files, modifications were made to a previous structure which existed in the area. The modifications were made as part of a 1968 application for permit for the structure. No modifications are known

to have occurred since the most recent design modifications. It should be noted that the construction of the design modifications are possibly incomplete. The design drawings for modifications, which are included in Appendix E, include a drainline control structure on the upstream slope of the dam. No control facilities for the drainline were observed for the inspection. Seeding of the embankment crest and slopes has not occurred or was not successful. The embankment crest and slopes remain barren of vegetation, and this condition has allowed continual erosion over the entire embankment.

e. Evaluation. No major deficiencies were observed during the inspection which were considered as having an immediate effect on the stability of the structure.

A minor seepage area was observed at the toe of the downstream slope near mid-embankment. The seepage was estimated at 1 gallon per minute. Erosion of the embankment crest and slopes has allowed material to deposit at the toe, causing the reported drainline outlet to be hidden from view.

An investigation should be made relative to the condition of the drainline and the outlet, and the cause of seepage should be investigated. General erosion of the embankment crest and slopes, if left to continue unchecked, could lead to potential stability problems.

Since no major immediate deficiencies were observed relative to the stability of the structure, the embankment is assumed to be statically stable. No calculations were performed to document this assumption.

f. Seismic Stability. The dam is located in seismic zone 1. No known seismic stability analyses have been performed. Since no immediate signs of instability were noted during the inspection, the embankment is assumed to be statically stable and capable of sustaining potential expected seismic loadings. No calculations were performed to document this assumption.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The Caledonia Water Company Dam appears to be in fair condition, but lacking in maintenance with regards to the drainline due to surface erosion of the embankment, crest and slopes. Surface erosion has caused silt and sand to be deposited at the toe of the dam, in the reported area of the drainline outlet. The outlet was not observed during the inspection. Soil erosion deposits have been allowed to continue unchecked and have apparently covered the outlet. No determination could be made with regards to the condition of the drainline and outlet.

A seepage area was observed at the downstream toe of the dam near mid-embankment. Seepage at the location was estimated to equal 1 gallon per minute. The cause of the seepage should be investigated and its potential effect on the long term stability of the structure determined.

Final construction of proposed modifications may not have been completed. No drainline control facility exists to regulate flow through the drainline, and final seeding of the embankment crest and slopes were either unsuccessful or never completed.

Observed obstructions at the entrance to, and in, the principal spillway channel were noted as having a potential effect on the discharge capacity of the spillway.

The Caledonia Water Company Dam is a high hazard-small size dam. The recommended spillway design flood (SDF) for a dam of this size and classification is in the range of 1/2 PMF to PMF. Since the height of dam is at the high end of the small size hazard category the spillway design flood has been selected as the PMF.

The visual observations, review of available data, hydrologic and hydraulic calculations and past operational performance indicate that the Caledonia Water Company Dam is capable of controlling approximately 29% of the PMF. The breach analysis and downstream routing of the flood wave did not indicate any increased potential for loss of life from that which existed just prior to failure of the dam. Therefore, the spillway is termed inadequate, but not seriously inadequate. If the embankment crest is raised to the design elevation 1156, the spillway is capable of passing the 1/2 PMF storm.

b. Adequacy of Information. Sufficient information is available to complete a Phase I report.

c. Urgency. The recommendations suggested below should be implemented immediately.

d. Necessity for Further Investigation. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required.

7.2 Recommendations/Remedial Measures.

1. A detailed hyrologic and hyraulic analysis should be conducted by a registered professional engineer knowledgeable in dam design and analysis to increase the spillway capacity.

2. The location of the water supply line should be determined and if the line passes through the embankment, provisions should be made for upstream closure of the line.

3. The outlet for the drainline should be located and uncovered. The condition of the exposed portion of the drainline and outlet should be determined. Necessary modifications in the area of the outlet should be made to insure the outlet remains visible and clear of the erosion debris.

4. The existence of a drainline control valve at the upstream end of the drainline should be verified. Control facilities for the valve should be made accessible for future use and inspection. It should be ascertained whether or not the valve is operable. If it is determined that the valve is operable, it should be operated and lubricated on a regular basis. If it is determined that the valve is not operable or non-existent, some means should be developed to drain the reservoir which does not include a pressurized line through the embankment.

5. The cause of the observed seepage should be investigated and its long term effect on the stability of the structure evaluated. The investigations should be conducted by a registered professional engineer knowledgeable in dam design and analysis. Remedial modifications should be conducted if required as a result of the evaluation.

6. The observed obstructions in the spillway should be removed. If the purpose of the obstructions placed in the spillway was to keep fish in the reservoir or collect debris at the entrance to the spillway, some other means should be devised for those purposes which does not retard the discharge potential of the spillway.

7. It should be determined whether the dam meets final design requirements associated with modifications required as part of the original permit application for the structure. If it is determined that the dam does not meet the designed modifications the owner should complete work on the structure as required, considering also the findings and recommendations of this inspection.

8. The embankment crest and slopes should be seeded to provide protective vegetation for the crest and slopes. Continued erosion in the area could lead to potential failure of the structure. Existing erosion areas should be repaired.

9. A warning system should be developed to warn downstream residents of large spillway discharges or imminent failure of the dam.

10. A regularly scheduled maintenance and operation plan should be implemeted to insure the continued safe operation of the structure.

11. A safety inspection program should be implemented with inspections at regular intervals by qualified personnel.

APPENDIX A
CHECKLIST, VISUAL INSPECTION, PHASE I

CHECK LIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Caledonia Water Company Dam COUNTY Franklin STATE Pennsylvania ID# PA 1143

TYPE OF DAM Earthfill HAZARD CATEGORY High

DATE(s) INSPECTION April 23, 1981 May 12, 1981 WEATHER Overcast with rain Clear and warm TEMPERATURE 45° 65°

POOL ELEVATION AT TIME OF INSPECTION 1152.0 M.S.L. TAILWATER AT TIME OF INSPECTION None M.S.L.

A-1

INSPECTION PERSONNEL:

R. Jeffrey Kimball, P.E. - L. Robert Kimball and Associates

James T. Hockensmith - L. Robert Kimball and Associates

O.T. McConnell - L. Robert Kimball and Associates

Mr. Richard Peace - Pennsylvania Department of Environmental Resources
Bureau of Dams and Waterway Management

O.T. McConnell RECORDER

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None noted.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None noted.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	The entire embankment crest and slopes show signs of erosion. No major erosion gullies were observed during the inspection.	The embankment crest and slopes should be seeded to reduce erosion.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Appears to be all right.	
RIPRAP FAILURES	Not applicable.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VEGETATION	None.	Protective seeding should be required at the facility.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appears to be all right.	
ANY NOTICEABLE SEEPAGE	Minor seepage observed at the toe of the dam near mid-embankment. Seepage estimated at 1 gallon per minute.	The cause of the seepage should be investigated.
STAFF GAUGE AND RECORDER	None.	
DRAINS	None observed.	

CONCRETE/MASONRY DAMS - NOT APPLICABLE

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE	Not applicable.	
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Not applicable.	
DRAINS	Not applicable.	
WATER PASSAGES	Not applicable.	
FOUNDATION	Not applicable.	

CONCRETE/MASONRY DAMS - NOT APPLICABLE

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	Not applicable.	
STRUCTURAL CRACKING	Not applicable.	
VERTICAL AND HORIZONTAL ALIGNMENT	Not applicable.	
MONOLITH JOINTS	Not applicable.	
CONSTRUCTION JOINTS	Not applicable.	
STAFF GAUGE OR RECORDER	Not applicable.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Not observed.	
INTAKE STRUCTURE	Not observed.	
OUTLET STRUCTURE	Not observed.	The outlet structure was unobserved due to surface runoff erosion which deposited debris in the area.
OUTLET CHANNEL	Small channel to Stump Run.	
EMERGENCY GATE	Not observed.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	The concrete weir in the principal spillway appeared to be in good condition. A 75 foot wide emergency spillway exists adjacent to the principal spillway.	The principal and emergency spillways are separated by an earthen berm.
APPROACH CHANNEL	Metal posts exist at the entrance to the principal spillway. The approach channel to the emergency spillway is approximately 50 foot long and temporarily unrestricted.	The posts should be removed at the approach to the principal spillway.
DISCHARGE CHANNEL	The discharge channels for the principal and emergency spillway consist of trapezoidal channels cut into natural ground.	The channel bottoms for the principal and emergency spillways are gravel lined.
BRIDGE AND PIERS	None.	

GATED SPILLWAY - NOT APPLICABLE

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable.	
APPROACH CHANNEL	Not applicable.	
DISCHARGE CHANNEL	Not applicable.	
BRIDGE AND PIERS	Not applicable.	
GATES AND OPERATION EQUIPMENT	Not applicable.	

DOWNSTREAM CHANNEL

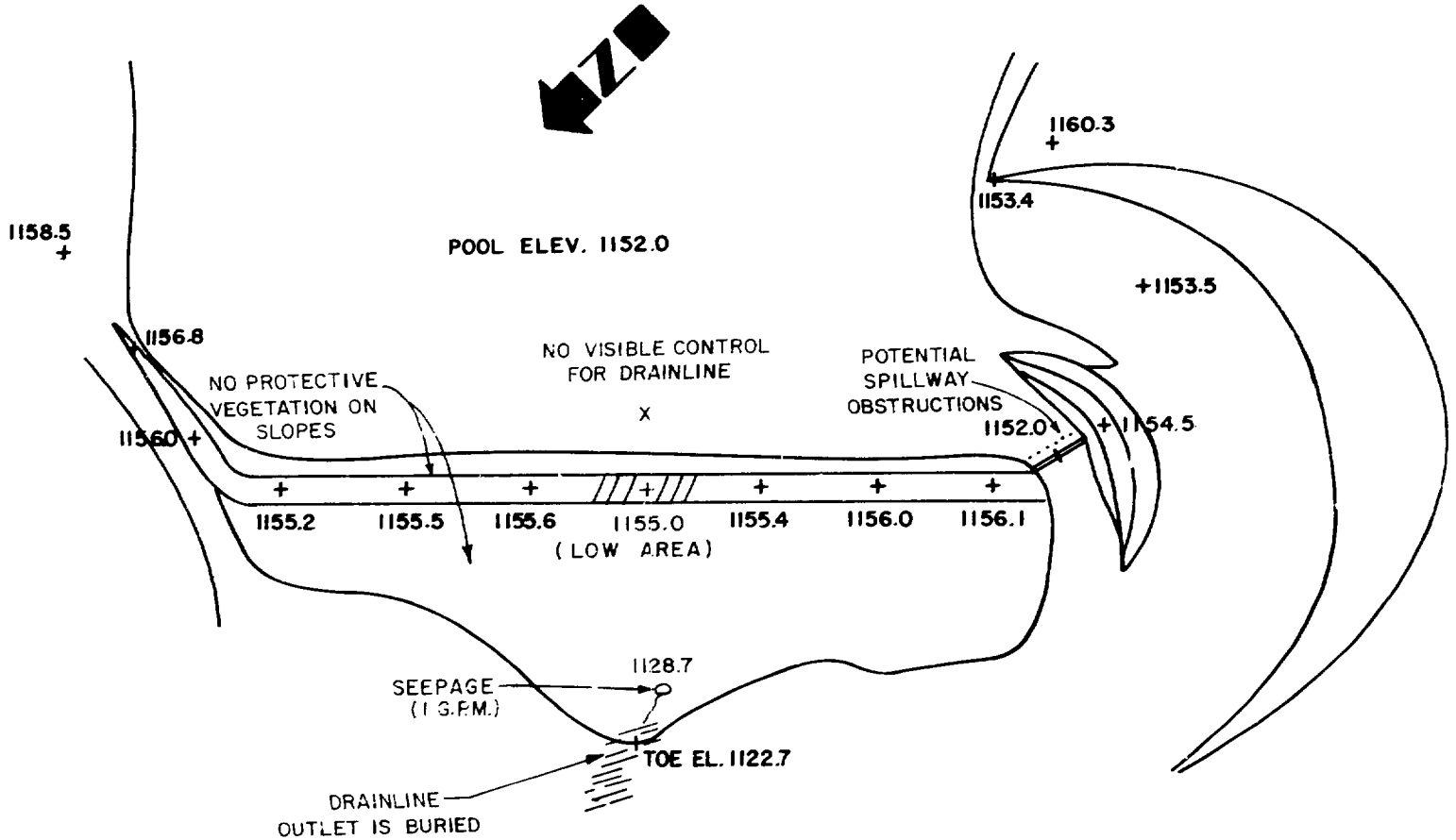
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The spillway discharge channels for the Caledonia Water Company Dam consist of trapezoidal shaped channels cut into natural ground. The channel bottoms are lined with gravel. No major obstructions were noted in the emergency spillway channel.	Gravel is piled in the principal spillway channel just below the concrete weir. Gravel should be removed or spread throughout the channel.
SLOPES	Appear to be stable.	
APPROXIMATE NO. OF HOMES AND POPULATION	At least three homes are located within the downstream potential flood plain of the dam. Residents located within the potential flood plain are estimated to equal 10 to 15 people. A small cottage [unoccupied at the time of inspection] exists approximately 1500 feet downstream of the dam.	At least three homes are located within 5 feet of the water surface elevation of the stream.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderate to steep. Appear to be stable.	
SEDIMENTATION	Unknown.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	Abandoned weir observed downstream of the reported location of the drainline outlet.	Weir most likely used to monitor required discharge at the facility.
PIEZOMETERS	None.	
OTHER	None.	



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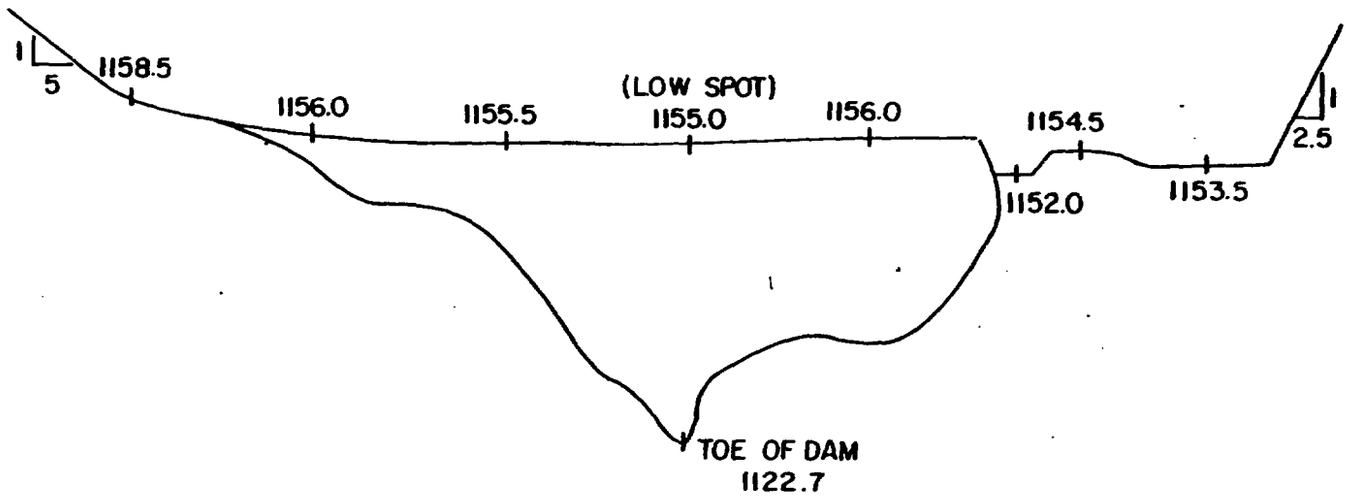
CALEDONIA WATER COMPANY DAM
APPROX. SCALE: 1" = 75'



PROFILE
LOOKING UPSTREAM
SCALE: HORIZ. 1" = 100'
VERT. 1" = 20'

CALEDONIA WATER COMPANY DAM

APPENDIX B
CHECKLIST, ENGINEERING DATA, DESIGN, CONSTRUCTION, OPERATION, PHASE I

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Caledonia Water Company Dam

ID# PA 1143

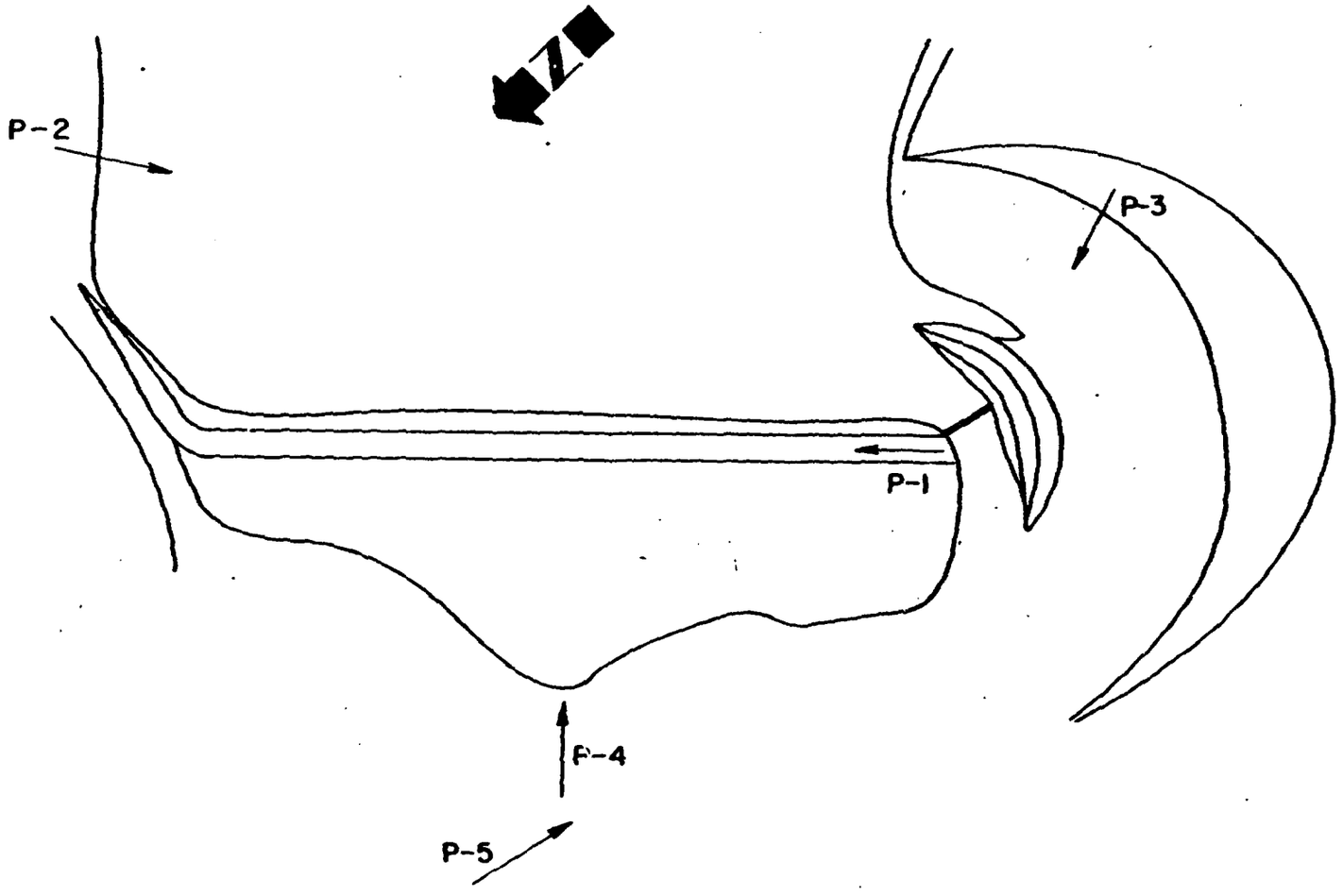
ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	U.S.G.S. quadrangle.
CONSTRUCTION HISTORY	None.
TYPICAL SECTIONS OF DAM	See Appendix E.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS RAINFALL/RESERVOIR RECORDS	None. None. None. None. None.

ITEM	REMARKS
DESIGN REPORTS	None.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Unknown.

ITEM	REMARKS
MONITORING SYSTEMS	None.
MODIFICATIONS	None known to have occurred since the original modifications.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None known to have occurred.
MAINTENANCE OPERATION RECORDS	None.

ITEM	REMARKS
SPILLWAY PLAN SECTIONS DETAILS	See Appendix E.
OPERATING EQUIPMENT PLANS & DETAILS	None.

APPENDIX C
PHOTOGRAPHS



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CALEDONIA WATER COMPANY DAM
PHOTO INDEX

P-INDICATES PHOTO LOCATION

CALEDONIA WATER COMPANY DAM
PA 1142

Sheet 1

Front

(1) Upper left - View of crest and downstream slope. Note lack of protective vegetation. View towards the right abutment.
(2) Upper right - View of emergency and principal spillway approach.
(3) Lower left - Close-up of principal spillway approach. Note metal posts along the spillway crest.
(4) Lower right - Reported location of drainline outlet. Note erosion deposits.

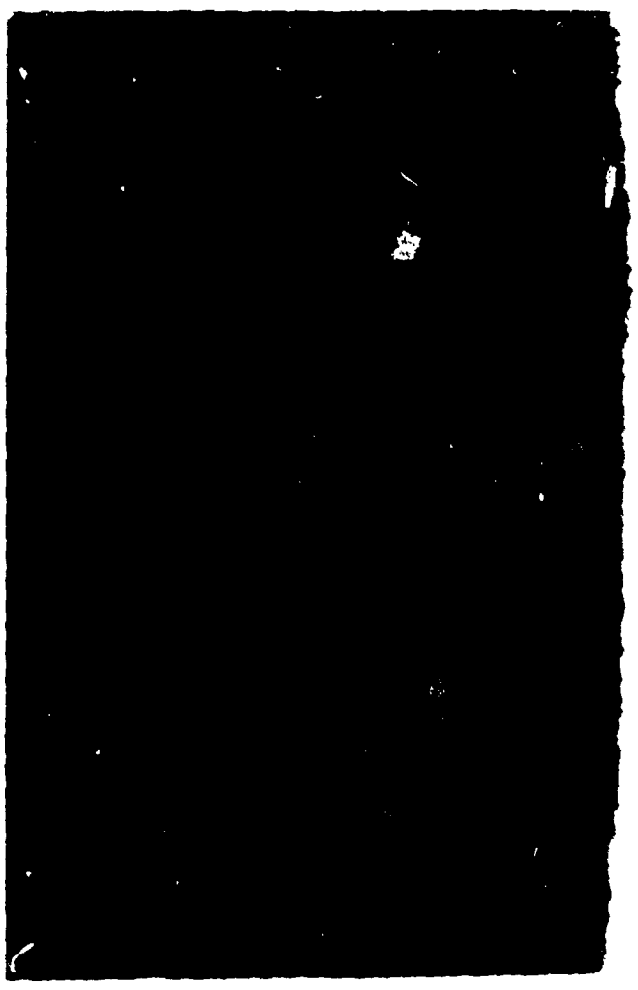
Sheet 1

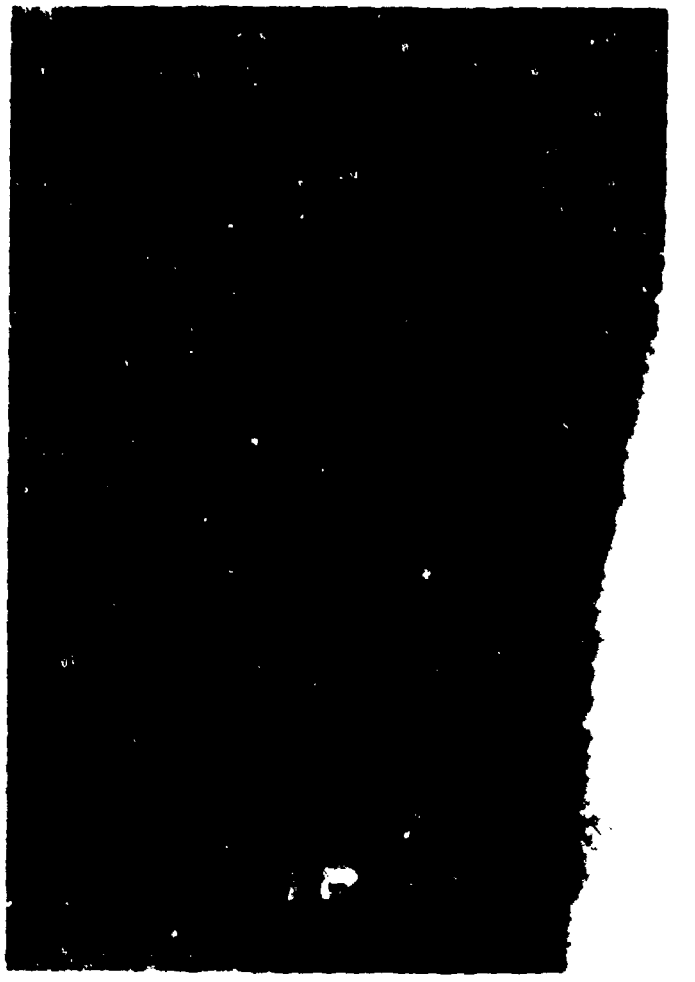
Back

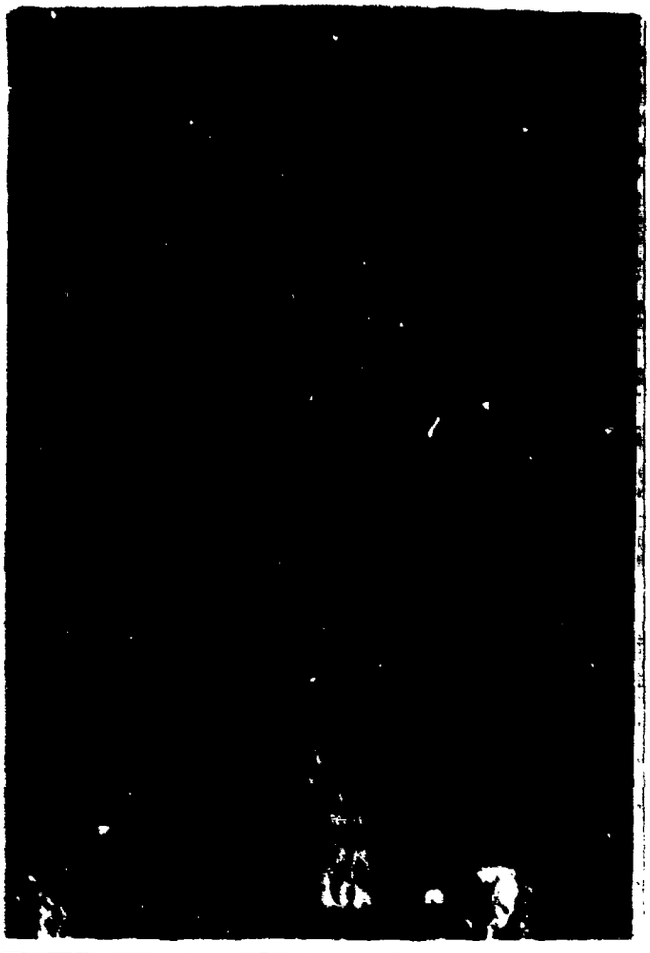
(5) Upper left - Abandoned weir.
(6) Upper right - Downstream exposure.

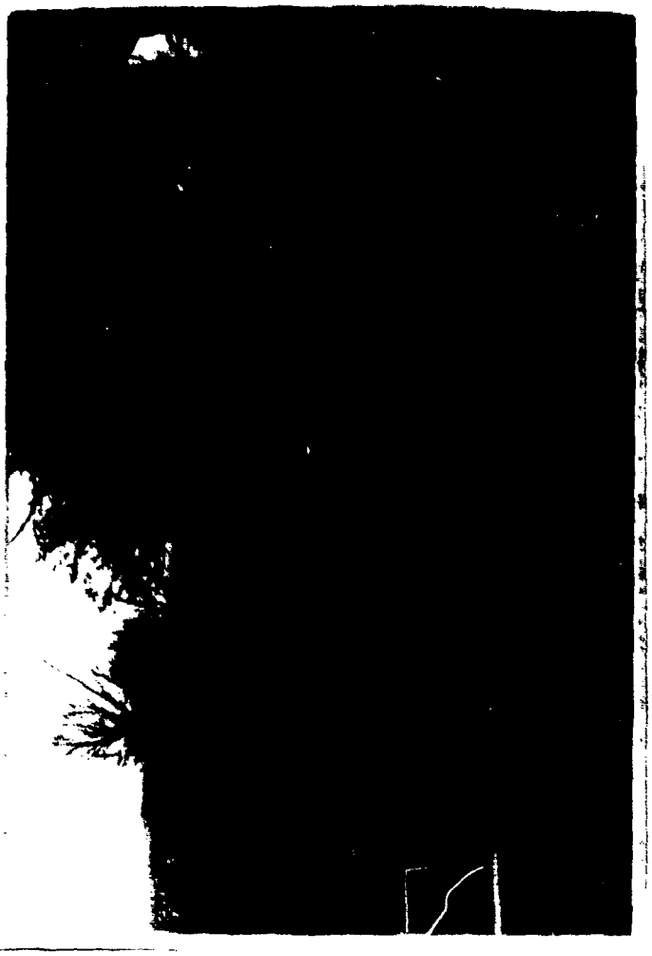
TOP OF PAGE

1,5	2,6
3	4









APPENDIX D
HYDROLOGY AND HYDRAULICS

APPENDIX D
HYDROLOGY AND HYDRAULICS

Methodology. The dam overtopping and breach analyses were accomplished using the systemized computer program HEC-1 (Dam Safety Investigation), September, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. A brief description of the methodology used in the analysis is presented below.

1. Precipitation. The Probable Maximum Precipitation (PMP) is derived and determined from regional charts prepared from past rainfall records including "Hydrometeorological Report No. 33" prepared by the U.S. Weather Bureau.

The index rainfall may be reduced from 10% to 20% depending on watershed size by utilization of what is termed the HOP Brook adjustment factor. Distribution of the total rainfall is made by the computer program using distribution methods developed by the Corps.

2. Inflow Hydrograph. The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for reservoir routing.

The unit hydrograph is developed using the Snyder method. This method requires calculation of several key parameters. The following list gives these parameters their definition and how they were obtained for these analysis.

Parameter	Definition	Where Obtained
Ct	Coefficient representing variations of watershed	From Corps of Engineers*
L	Length of main stream channel miles	From U.S.G.S. 7.5 minute topgraphic
Lca	Length on main stream to centroid of watershed	From U.S.G.S. 7.5 minute topographic
Cp	Peaking coefficient	From Corps of Engineers*
A	Watershed size	From U.S.G.S. 7.5 minute topographic

*Developed by the Corps of Engineers on a regional basis for Pennsylvania.

3. Routing. Reservoir routing is accomplished by using Modified Plus routing techniques where the flood hydrograph is routed through reservoir storage. Hydraulic capacities of the outlet works, spillways and the crest of the dam are used as outlet controls in the routing.

The hydraulic capacity of the outlet works can either be calculated and input, or sufficient dimensions input, and the program will calculate an elevation discharge relationship.

Storage in the pool area is defined by an area - elevation relationship from which the computer calculates storage. Surface areas are either planimetered from available mapping or U.S.G.S. 7.5 minute series topographic maps or taken from reasonably accurate design data.

4. Dam Overtopping. Using given percentages of the PMF, the computer program will calculate the percentage of the PMF, which can be controlled by the reservoir and spillway without the dam overtopping.

5. Dam Breach and Downstream Routing. The computer program is equipped to determine the increase in downstream flooding due to failure of the dam caused by overtopping. This is accomplished by routing both the pre-failure peak flow and the peak flow through the breach (calculated by the computer with given input assumptions) at a given point in time and determining the water depth in the downstream channel. Channel cross-sections taken from U.S.G.S. 7.5 minute topographic maps were used in the downstream flood wave routing. Pre and post failure water depths are calculated at locations where cross-sections are input.

HYDROLOGY AND HYDRAULICS ANALYSIS
DATA BASE

NAME OF DAM: Caledonia Water Company Dam

PROBABLE MAXIMUM PRECIPITATION (PMP) = 23.7 inches

STATION	1	2	3
Station Description	Caledonia Water Company Dam		
Drainage Area (square miles)	1.0		
Cumulative Drainage Area (square miles)	1.0		
Adjustment of PMF for Drainage Area (%)(1)	(Zone 6)		
6 hours	113		
12 hours	123		
24 hours	132		
48 hours	143		
72 hours	N/A		
Snyder Hydrograph Parameters			
Zone (2)	32		
Cp (3)	0.75		
Ct (3)	1.90		
L (miles) (4)	1.89		
Lca (miles) (4)	1.0		
tp = Ct(LxLca) $^{0.3}$ hrs.	2.3		
Spillway Data (principal)			
Crest Length (ft)	24		
Freeboard (ft)	3.0		
Discharge Coefficient	3.2		
Exponent	1.5		

(1) Hydrometeorological Report 33 (Figure 1), U.S. Weather Bureau and U.S. Army Corps of Engineers, 1956.
(2) Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's coefficients (C_p and C_t).
(3) Snyder's Coefficients.
(4) L=Length of longest water course from outlet to basin divide. L_{ca}=Length of water course from outlet to point opposite the centroid of drainage area.

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 1.0 sq.mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1152.0 [12 ac-ft]

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1155.0 [17 ac-ft]

ELEVATION MAXIMUM DESIGN POOL: 1156

ELEVATION TOP DAM: 1155 [low spot]

SPILLWAY CREST:

a. Elevation 1152
b. Type Trapezoidal with concrete weir
c. Width 24 feet
d. Length 80 feet
e. Location Spillover Left abutment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type Unknown
b. Location Unknown
c. Entrance inverts Unknown
d. Exit inverts Unknown
e. Emergency drawdown facilities Unknown

HYDROMETEOROLOGICAL GAUGES:

a. Type None
b. Location None
c. Records None

MAXIMUM NON-DAMAGING DISCHARGE: Unknown

NOTE: Elevations refer to MSL.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

NAME CALEDONIA MINES CO.
NUMBER PA-1142
SHEET NO. 1 OF
BY DTP DATE 6-81

LOSS RATE AND BASE FLOW PARAMETERS

STRTL = 1 INCH
CNSTL = 0.05 IN/HR
STRTQ = 1.5 C.F.S./M.I.^{2}
QRCSN = 0.05 (5% OF PEAK FLOW)
RTIOR = 2.0

AS RECOMMENDED BY THE BALTIMORE DISTRICT CORPS OF ENGINEERS.

ELEVATION-AREA-CAPACITY RELATIONSHIPS

FROM U.S.G.S. 7.5 MIN. QUAD., D.E.R. FILES AND FIELD INSPECTION DATA.

PRINCIPAL SPILLWAY CREST ELEVATION = 1152.0
EMERGENCY SPILLWAY CREST @ ELEV. = 1153.5
TOP OF DAM (LOW SPOT) @ ELEVATION = 1155.0
HEIGHT OF DAM = 1155.0 - 1122.7 = 32.3'

FROM THE CONIC METHOD FOR RESERVOIR VOLUME. FLOOD HYDROGRAPH PACKAGE (HEC-1), DAM SAFETY VERSION (USER'S MANUAL).

$H \simeq 3 Y_1 / A$
$1152 - 1122.7 = 3 Y_1 / 1.2$
$Y_1 = 11.72$ AC. FT } BELOW EL. 1152

VOLUME AT TOP OF DAM (V_T)

$V_T = Y_1 + h'(1.2 + 2.1 + \sqrt{1.2 \times 2.1}/3)$
$= 11.7 + [3(4.89)/3]$
$= 11.72 + 4.89$
$= 16.61$ AC. FT } TOTAL VOL. EST.

AT ELEV. 1180, AREA = 4.5 ACRES.

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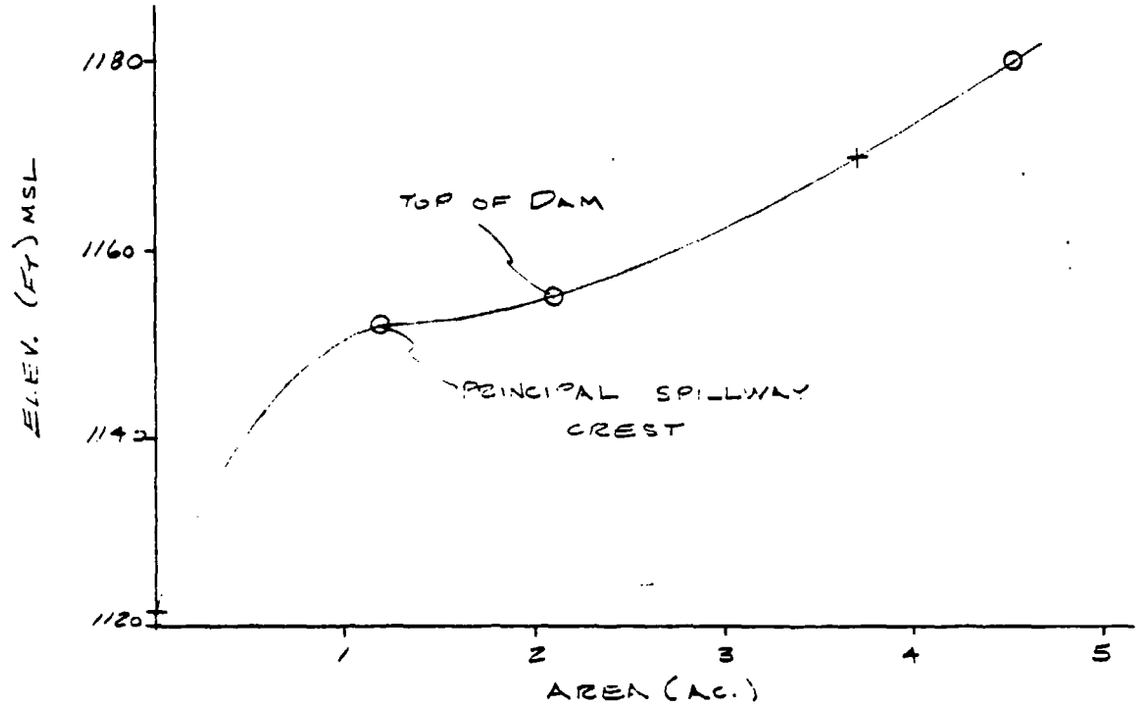
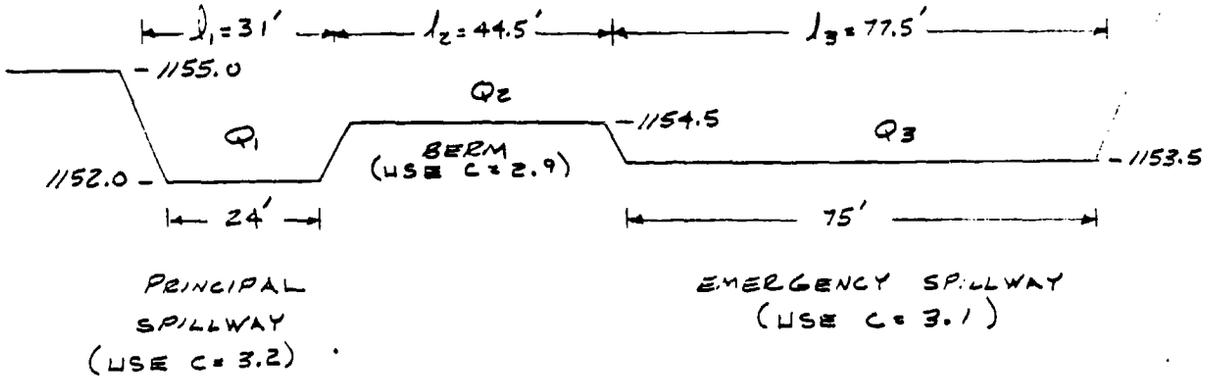
NAME
NUMBER PA-112
SHEET NO. 2 OF
BY OTM DATE 6-81



AREA (AC)	0	1.2	2.1	3.7	4.5
ELEV. (FT.)	1122.7	1152	1155	1170	1180

DISCHARGE RATING CURVE

SPILLWAY PROFILE



NOTE: THE DISCHARGE FACILITIES FOR THIS DAM CONSISTS OF TWO (2) TRAPEZOIDAL SPILLWAYS SEPERATED BY AN EARTHEN BERM. TO SIMPLIFY THE ANALYSIS OF THE DISCHARGE CAPABILITIES OF STRUCTURES THE STANDARD WEIR EQUATION WAS SELECTED. LENGTH OF WEIR WAS CONSIDERED TO BE THE AVERAGE LENGTH OF CREST. APPROPRIATE COEFFICIENTS OF DISCHARGE WERE SELECTED FOR EACH SECTION.

ELEV. (FT)	PRINCIPAL		BERM		EMERGENCY		DISCHARGE
	h_1 (FT)	Q_1 (cfs)	h_2 (FT)	Q_2 (cfs)	h_3 (FT)	Q_3 (cfs)	*Q (cfs)
1152.0	0	0					0
1152.5	0.5	30					30
1153.0	1	100					100
1153.5	1.5	180			0	0	180
1154.0	2	280			0.5	80	360
1154.5	2.5	390	0	0	1	240	630
1155.0	3	510	0.5	50	1.5	440	1000
1156.0	4	790	1.5	240	2.5	950	1980
1157.0	5	1110	2.5	510	3.5	1570	3190
1158.0	6	1460	3.5	840	4.5	2290	4590

*VALUES ROUNDED TO NEAREST 10 cfs.

OVERTOPPING

TO BE DETERMINED BY (HEC-1), $L, $V OPTION.
COEFFICIENT OF DISCHARGE "C" = 2.9

$L	100'	350'	410'	445
$V	1055	1056	1057	1058

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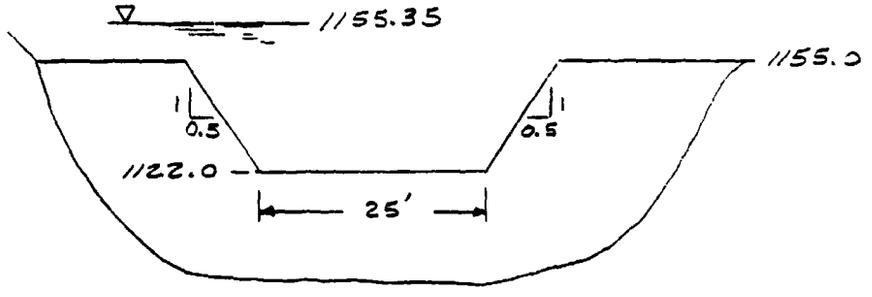
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

NAME
NUMBER PA-1142
SHEET NO. 4 OF
BY STM DATE 7-81

BREACH ANALYSIS

CONSIDER 0.35 FEET (4.20 IN.) OF OVERTOPPING FOR APPROXIMATELY 2.5 HOURS, SUFFICIENT TO CAUSE FAILURE OF THE DAM.

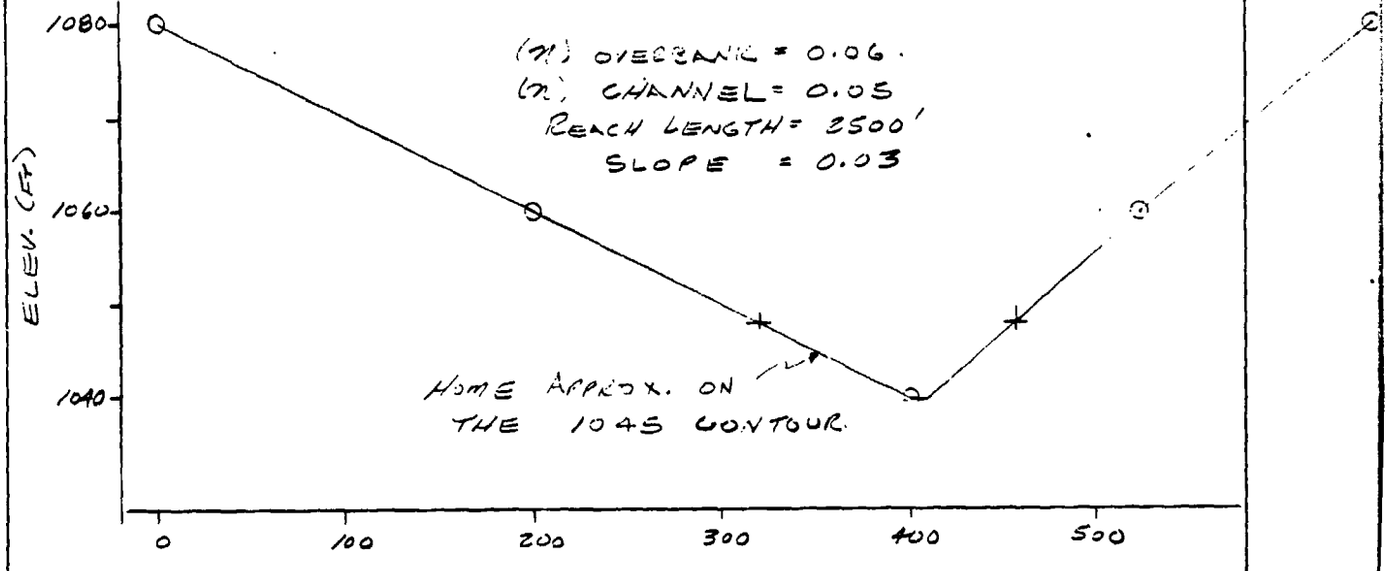


NOT TO SCALE

BRWID = 25 FT.
Z = 0.5
ELBM = 1122.0
TFAIL = 1 HR
WSEL = 1152.0
FAILEL = 1155.35

CHANNEL ROUTING

REACH NO. 1 (STATION NO. 3) - VIEWING DOWNSTREAM



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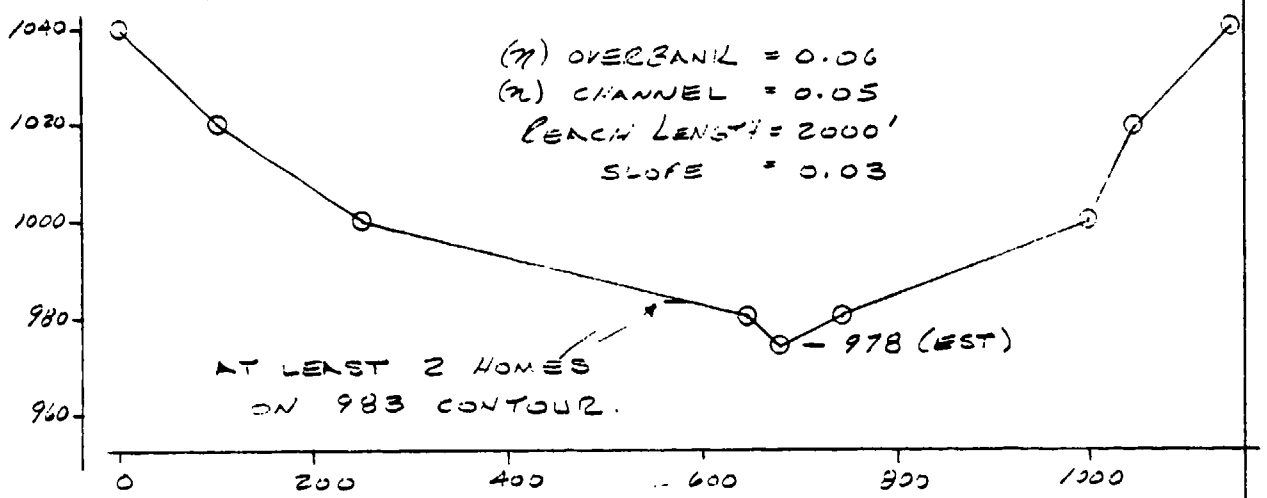
EBENSBURG PENNSYLVANIA

NAME
NUMBER PA-42
SHEET NO. 5 OF
BY O.M DATE 7/91

REACH NO. 2 (STATION NO. 4) - VIEWING DOWNSTREAM



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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************
    1                 A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF THE PMF
    2                 A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF THE CALEDONIA WATER CO. DAM
    3                 A3       RATIOS OF THE PMF ROUTED THROUGH THE RESERVOIR (PA-1143)
    4                 B     288        0       10        0        0        0        0        0        0        0
    5                 B1      5
    6                 J       1        6        1
    7                 J1     .2       .3       .4       .5       .6        1
    8                 K       0        1                                          1
    9                 K1        INFLOW
   10                 M       1        1      1.0                                1                         1
   11                 P               23.7      113      123      132      143
   12                 T                                                          1.0     0.05
   13                 W     2.3     0.75
   14                 X    -1.5     -.05      2.0
   15                 K       1        2                                          1
   16                 K1        ROUTE
   17                 Y                                  1        1
   18                 Y1      1                                                -1152       -1
   19                 Y4   1152   1152.5     1153   1153.5     1154   1154.5     1155     1156     1157     1158
   20                 Y5      0       30      100      180      360      630     1000     1980     3190     4590
   21                 SA      0      1.2      2.1      3.7      4.5
   22                 SE1122.7     1152     1155     1170     1180
   23                 SS   1152
   24                 SD   1155      2.9      1.5      100
   25                 SL    100      350      410      445
   26                 SV   1155     1056     1057     1058
   27                 K      99
```

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80
****

RUN DATE= 81/06/26.
TIME= 09.07.08.

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF THE PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF THE CALEDONIA WATER CO. DAM
RATIOS OF THE PMF ROUTED THROUGH THE RESERVOIR (PA-1143)

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
266	0	10	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 6 LRTIO= 1

RTIOS= .20 .30 .40 .50 .60 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	1	1.00	0.00	1.00	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	23.70	113.00	123.00	132.00	143.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.00	.05	0.00	0.00

UNIT HYDROGRAPH DATA

TP= 2.30 CP= .75 NTA= 0

RECESSION DATA
STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=16.54 AND R= 8.38 INTERVALS

UNIT HYDROGRAPH 54 END-OF-PERIOD ORDINATES. LAG= 2.28 HOURS. CP= .74 VOL= 1.00

5.	17.	34.	54.	76.	98.	120.	143.	165.	184.
199.	209.	214.	216.	213.	206.	192.	172.	152.	135.
120.	107.	95.	84.	74.	66.	59.	52.	46.	41.
36.	32.	29.	25.	23.	20.	18.	16.	14.	12.
11.	10.	9.	8.	7.	6.	5.	5.	4.	4.
3.	3.	3.	2.						

FLOW	0.00	30.00	100.00	180.00	360.00	630.00	1000.00	1980.00	3190.00
//4590.00									
SURFACE AREA=	0.	1.	2.	4.	5.				
CAPACITY=	0.	12.	17.	50.	100.				
ELEVATION=	1123.	1152.	1155.	1170.	1180.				

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
1152.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1155.0	2.9	1.5	100.

CREST LENGTH	100.	350.	410.	445.
AT OR BELOW ELEVATION	1155.0	1056.0	1057.0	1058.0

PEAK OUTFLOW IS 721. AT TIME 41.83 HOURS

PEAK OUTFLOW IS 1082. AT TIME 41.83 HOURS

PEAK OUTFLOW IS 1443. AT TIME 41.83 HOURS

PEAK OUTFLOW IS 1803. AT TIME 41.83 HOURS

PEAK OUTFLOW IS 2164. AT TIME 41.83 HOURS

PEAK OUTFLOW IS 3607. AT TIME 41.83 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS					
				RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 .60	RATIO 6 1.00
HYDROGRAPH AT	1	1.00	1	721.	1082.	1443.	1804.	2164.	3607.
	(	2.59)	(	20.43)(	30.64)(	40.86)(	51.07)(	61.29)(	102.15)(
ROUTED TO	2	1.00	1	721.	1082.	1443.	1803.	2164.	3607.
	(	2.59)	(	20.42)(	30.63)(	40.85)(	51.05)(	61.29)(	102.14)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1152.00	1152.00	1155.00
STORAGE	12.	12.	17.
OUTFLOW	0.	0.	1000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	1154.62	0.00	18.	721.	0.00	41.83	0.00
.30	1155.08	.08	17.	1082.	1.17	41.83	0.00
.40	1155.38	.38	17.	1443.	2.83	41.83	0.00
.50	1155.65	.65	18.	1803.	3.83	41.83	0.00
.60	1155.91	.91	19.	2164.	4.50	41.83	0.00
1.00	1156.75	1.75	20.	3607.	6.50	41.83	0.00

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
  LAST MODIFICATION  01 APR 80
**********
    1              A1     RATIOS OF PMF ROUTED THROUGH THE RESERVOIR AND DOWNSTREAM
    2              A2     DOWNSTREAM CONDITION DUE TO OVERTOPPING OF CALEDONIA WATER CO. DAM
    3              A3     PLAN 1 ASSUMES BREACH. PLAN 2 ASSUMES NO BREACH (PA-1143)
    4              B   288       0      10       0       0       0       0       0       0       0
    5              B1    5
    6              J     2       1       1
    7              J1  0.4
    8              K     0       1                                       1
    9              K1      INFLOW
   10              M     1       1     1.0                       1                       1
   11              P           23.7     113     123     132     143
   12              T                                                 1.0    0.05
   13              R   2.3    0.75
   14              X  -1.5    -.05     2.0
   15              K     1       2                                       1
   16              K1      ROUTE
   17              Y                                       1       1
   18              Y1    1                                                 -1152      -1
   19              Y4 1152  1152.5    1153  1153.5    1154  1154.5    1155    1156    1157    1158
   20              Y5    0      30     100     180     360     630    1000    1980    3190    4590
   21              $A    0     1.2     2.1     3.7     4.5
   22              $E1122.7    1152    1155    1170    1180
   23              $$ 1152
   24              $D 1155     2.9     1.5     100
   25              $L  100     350     410     445
   26              $V 1155    1056    1057    1058
   27              $B   25     0.5    1122       1    1152 1155.35
   28              $B   25     0.5    1122       1    1152    1170
   29              K     1       3                                       1
   30              K1      MOD-PULS STREAM ROUTING (REACH 1)
   31              Y                                       1       1
   32              Y1    1
   33              Y6  .06     .05     .06    1040    1080    2500   0.03
   34              Y7    0    1080     200    1060     325    1048     400    1040     410    1040
   35              Y7  460    1048     525    1060     650    1080
   36              K     1       4                                       1
   37              K1      MOD-PULS STREAM ROUTING (REACH 2)
   38              Y                                       1       1
   39              Y1    1
   40              Y6  .06     .05     .06     978    1040    2000     .03
   41              Y7    0    1040     100    1020     250    1000     650     980     680     978
   42              Y7  690     978    1000    1000    1150    1040
   43              K    99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .40
				RATIOS APPLIED TO FLOWS
HYDROGRAPH AT	1	1.00 (2.59)	1	1443. (40.86)
			2	1443. (40.86)
ROUTED TO	2	1.00 (2.59)	1	1979. (56.04)
			2	1443. (40.85)
ROUTED TO	3	1.00 (2.59)	1	1890. (53.51)
			2	1440. (40.79)
ROUTED TO	4	1.00 (2.59)	1	1871. (52.99)
			2	1441. (40.79)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1152.00	1152.00	1155.00
STORAGE	12.	12.	17.
OUTFLOW	0.	0.	1000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	1155.36	.96	17.	1979.	1.38	42.00	41.50

PLAN 2 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1152.00	1152.00	1155.00
STORAGE	12.	12.	17.
OUTFLOW	0.	0.	1000.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.40	1155.38	.38	17.	1443.	2.83	41.83	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW.CFS	MAXIMUM STAGE.FT	TIME HOURS
.40	1890.	1044.4	42.00

PLAN 2 STATION 3

RATIO	MAXIMUM FLOW.CFS	MAXIMUM STAGE.FT	TIME HOURS
.40	1440.	1043.9	41.83

PLAN 1 STATION 4

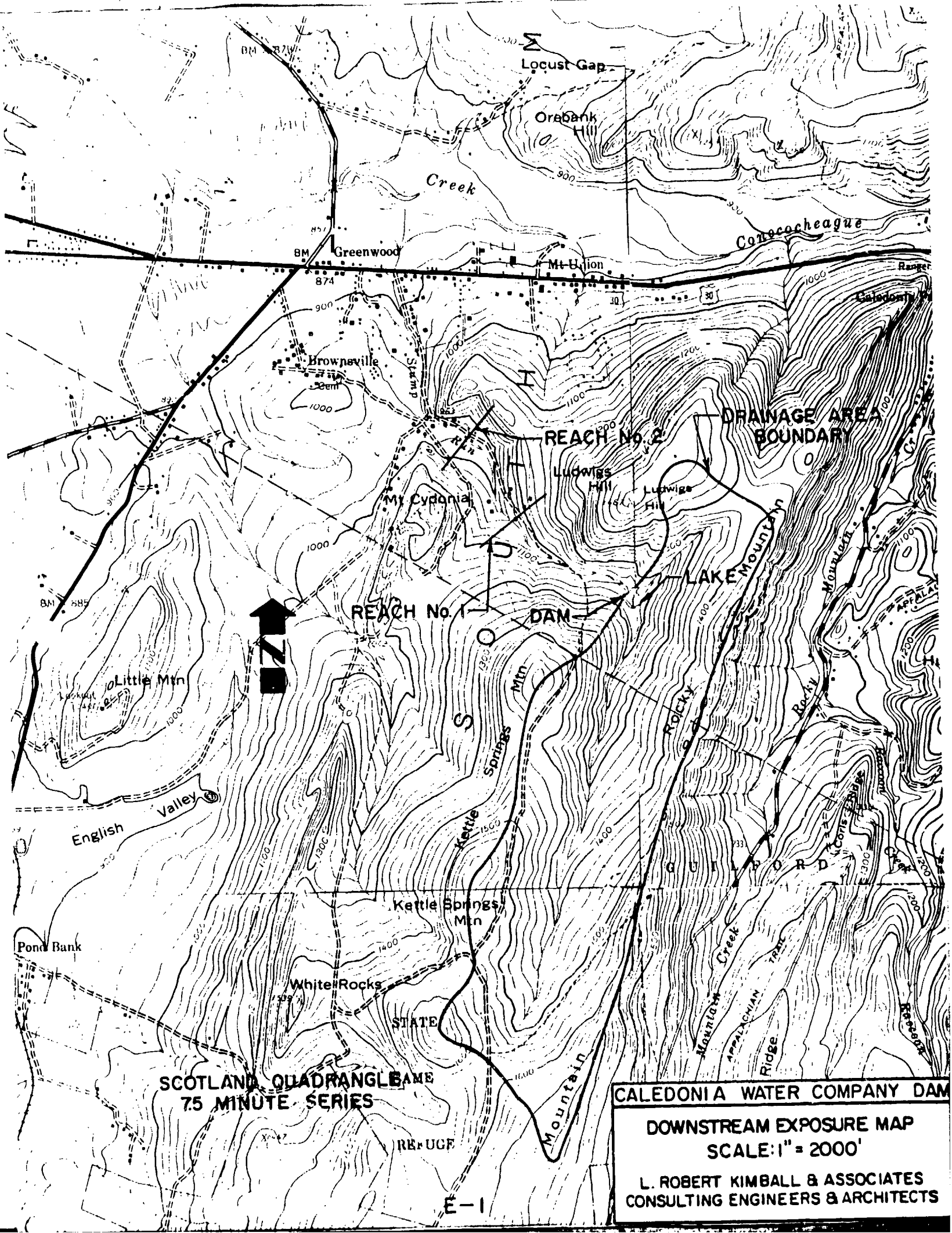
RATIO	MAXIMUM FLOW.CFS	MAXIMUM STAGE.FT	TIME HOURS

.40	1871.	981.5	42.17

PLAN 2 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.40	1441.	981.3	42.00

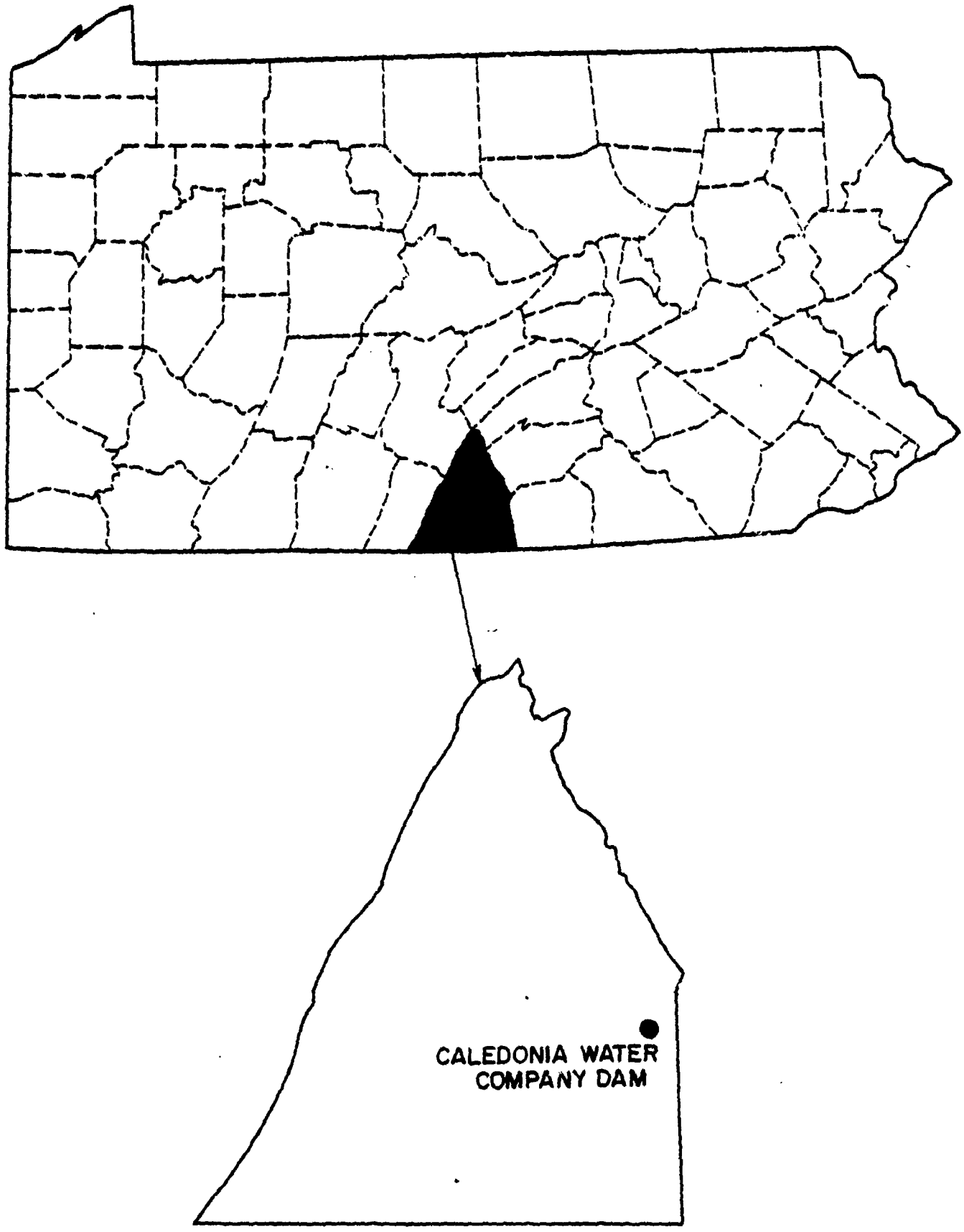
APPENDIX-E
DRAWINGS



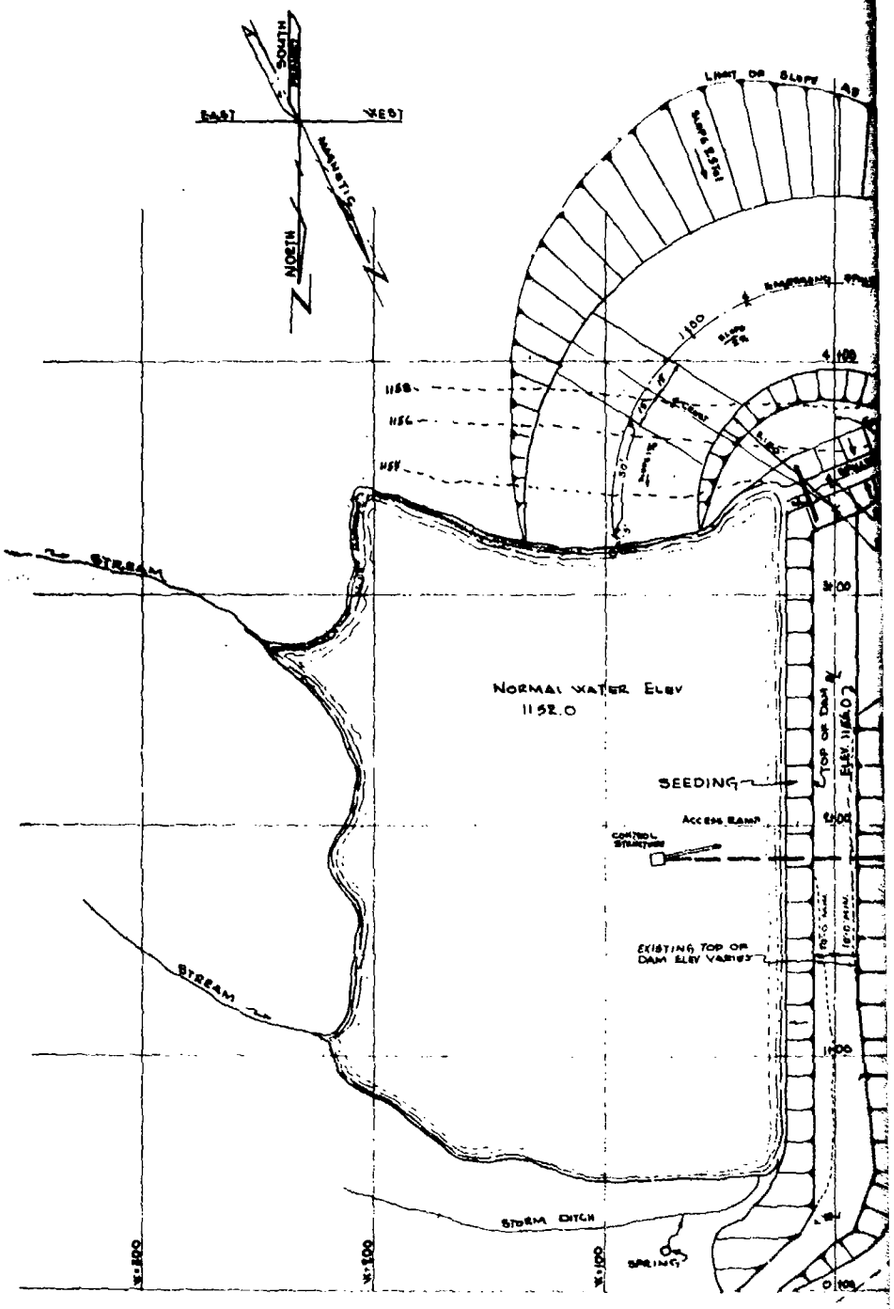
CALEDONIA WATER COMPANY DAM

DOWNSTREAM EXPOSURE MAP
SCALE: 1" = 2000'

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS



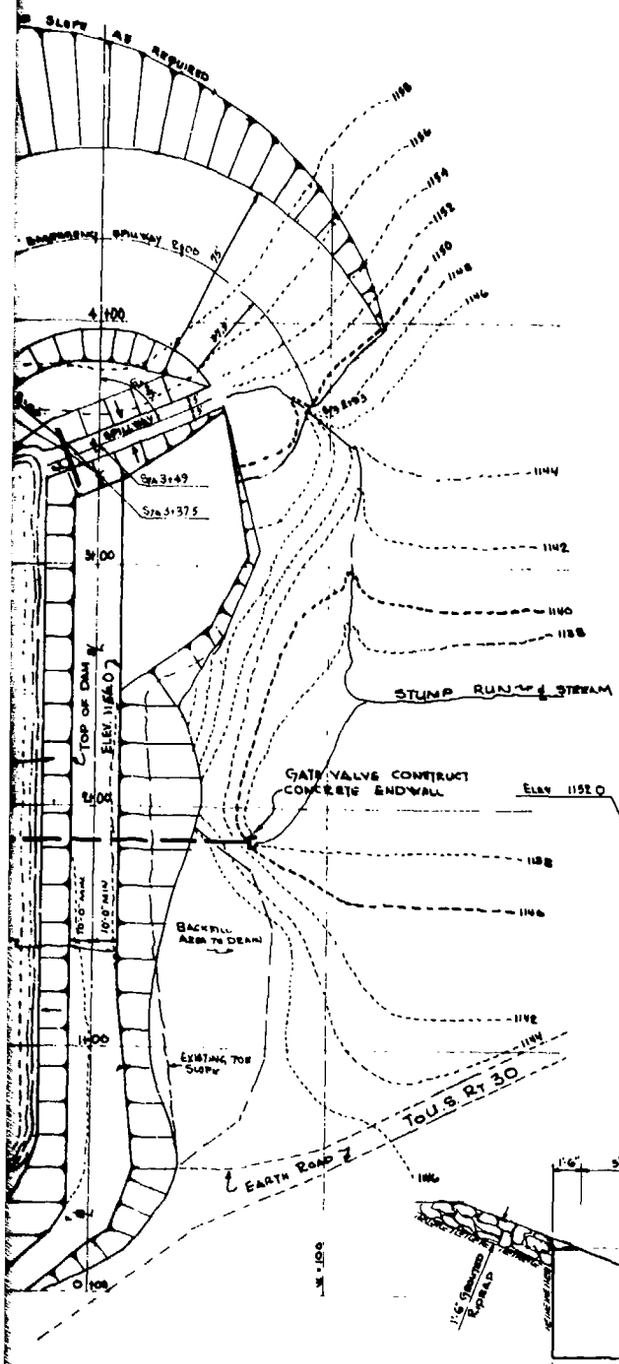
SITE LOCATION MAP
FRANKLIN COUNTY, PENNSYLVANIA

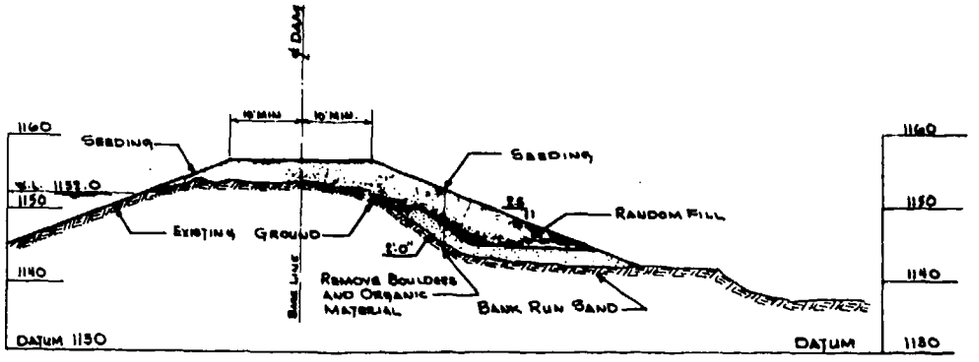


GENERAL PLAN

SCALE 1"=50'

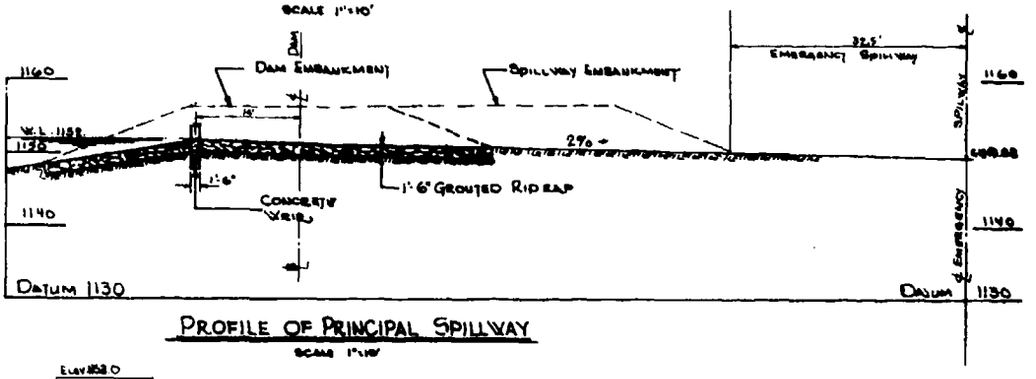
Note:- Topography Taken From Survey
By Arrowood Inc. Dated July 1968





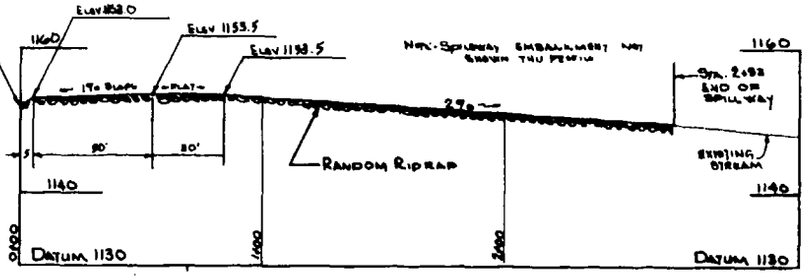
TYPICAL EMBANKMENT SECTION

SCALE 1"=10'



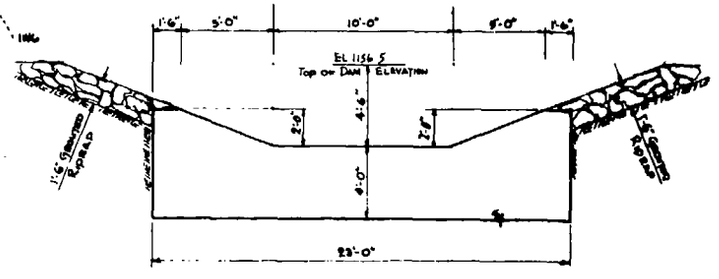
PROFILE OF PRINCIPAL SPILLWAY

SCALE 1"=10'



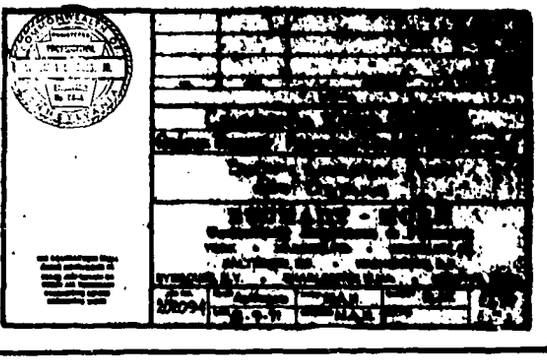
PROFILE OF EMERGENCY SPILWAY

SCALE:- HORIZ 1"= 20' VERT 1"=10'



DETAIL OF CONCRETE WEIR

SCALE 1"=4'-0"



1

2

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS

APPENDIX F
GEOLOGY

General Geology

The Caledonia Water Company Dam is located in the Blue Ridge Physiographic Province which lies to the east of the Great Valley Section of the Valley and Ridge province. The southern division of the Appalachians, of which South Mountain is the northern end, is known as the Blue Ridge Province. South Mountain is composed of a number of parallel ridges that trend northeastward, separated by narrow valleys. The ridges are covered with forests, and on many parts of their west flanks large boulder fields extend from summits to valley floors. South Mountain consists of a core of pre-Cambrian igneous rocks which are overlain unconformably by sedimentary rocks, chiefly sandstone and shale of Cambrian age.

The bedrock underlying the dam and exposed locally consists of dark greenish gray phyllite and schist with thin quartzite layers. These rocks belong to the Harpers Formation of Cambrian Age.

GEOLOGIC MAP OF THE AREA AROUND THE CALEDONIA WATER COMPANY DAM AND THE K-SECTION DAM
SCALE 1:250,000

TRIASSIC

Diabase
Dark gray, medium to coarse grained; composed chiefly of gray plagioclase feldspar and black or green augite

Brunswick Formation or Gettysburg Formation
Brunswick and Gettysburg-Red to brown, fine to coarse grained quartzose sandstone with red shale interbeds, interbedded shale and limestone conglomerate, and quartz pebble conglomerate. Heidlersburg Member consists of gray arkosic sandstone with interbedded red shale, quartz pebble conglomerate and limestone conglomerate

Lockatong Formation
Dark gray to black, thick bedded argillite with occasional zones of thin bedded black shale, locally has thin layers of impure limestone or calcareous shale

Stockton Formation or New Oxford Formation
Stockton and New Oxford- Light gray to buff, coarse grained arkosic sandstone and conglomerate, red and brown fine grained, siliceous sandstone and red shale

Csh

CAMBRIAN

GREAT VALLEY AND PIEDMONT

Antietam Formation
Gray, buff weathering quartzite and quartz schist.

Harpers Formation
Dark greenish gray phyllite and schist with thin quartzite layers; includes Montalto Member Cms, gray quartzite.

Chickies Formation or Weverton Formation
Chickies- Light gray, hard, massive, sericithus-bearing quartzite and quartz schist; thin interbedded dark slate at top; conglomerate (Hellam Member) at base. Weverton- Equivalent to Chickies; gray to purplish gray, feldspathic quartzite and quartzose conglomerate in hard resistant beds containing rounded pebbles; sericitic slate and purplish gray, crumbly, poorly sorted, arkosic sandstones and conglomerates (Loudoun Formation) at base.

Cha

Hardyston Formation
Quartzite with conglomerate at the base.